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FIRE TESTS OF POLYBENZIMIDAZOLE (PBI) BLENDS

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23	05	04	POLYBENZIMIDAZOLE	40/60 PBI/NOMEX	NOMEX III
			95/5 NOMEX/KEVLAR	20/80 PBI/NOMEX I	PBI

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FULL SCALE FUEL FIRE PIT TESTS WERE PERFORMED ON THREE DIFFERENT GROUPS OF COVERALLS. THE PURPOSE OF THESE TESTS WAS TO COMPARE THE FIRE PROTECTIVE QUALITY OF POLYBENZIMIDAZOLE (PBI) BLENDED WITH OTHER FABRICS. THE COMPOSITION OF THE FIRST GROUP WAS A 40% PBI/60% KEVLAR BLEND. THE SECOND GROUP WAS COMPOSED OF A 20% PBI/80% NOMEX I BLEND, AND THE THIRD GROUP WAS TESTED AS A CONTROL: STANDARD NOMEX III, WHICH IS A 95% NOMEX/5% KEVLAR BLEND. THIS IS THE SAGE GREEN COVERALL CURRENTLY BEING USED BY THE AIR FORCE (27P) and NAVY (73P). THE TESTS WERE CONDUCTED AT THE NAVAL AIR DEVELOPMENT CENTER'S FUEL FIRE TEST FACILITY. ALTHOUGH THE SAMPLE SIZE WAS SMALL, THE RESULTS SHOWED THAT THE PBI BLENDS WITHSTOOD THESE EXTENDED DURATION EXPOSURES VERY WELL WHEN COMPARED TO THE STANDARD. Keywords: Fire Resistant textiles, Polybenzimidazole Plastics, Heat resistant plastics. (AUTH)

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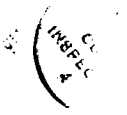

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ABSTRACT

Full scale fuel fire pit tests were performed on three different groups of coveralls. The purpose of these tests was to compare the fire protective quality of two Polybenzimidazole (PBI) blends and Nomex III. The composition of the first group of coveralls was a 40% PBI/60% Kevlar blend. The second group was composed of a 20% PBI/80% Nomex I blend. And the third group of suits was tested as a control: standard Nomex III, which is a 95% Nomex/5% Kevlar blend. This is the standard sage green coverall currently being used by the Air Force (27/P) and Navy (73/P). The tests were conducted at the Naval Air Development Center's Fuel Fire Test Facility. Although the sample size was small, the results showed that the PBI blends withstood these extended duration exposures very well when compared with the standard.

INTRODUCTION

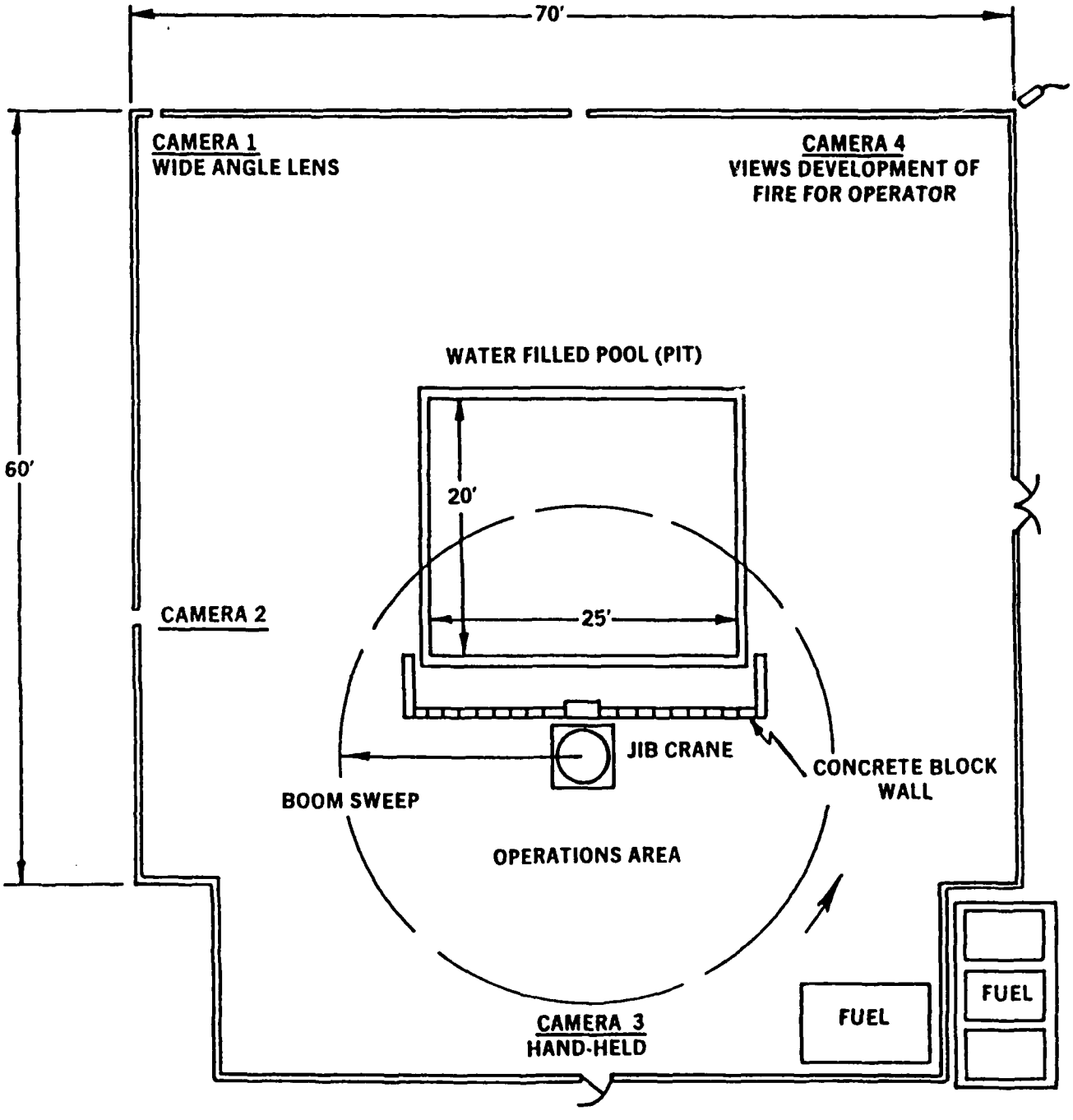
Fire testing arises from a need to provide personnel with the optimum protection should they be exposed to fires while on duty, especially fires arising from burning fuel. Clothing assemblies being next to the wearer are the most immediate line of protection. The nature of clothing materials is such that exposure to heat and flames may broadly produce one of three reactions: 1) they may ignite and burn providing an additional hazard, 2) they may be essentially consumed by heat leaving a degraded residue, providing no protection, and 3) they may survive providing resistance to the passage of heat to the wearer. The difference between 2 and 3 is often a function of the length of the exposure.

The purpose of this report is to record the testing of 4.5 oz. 40% PBI/60% Kevlar, 4.7 oz. piece dyed 20% PBI/80% Nomex I and 4.5 oz. solution dyed Nomex III coveralls. Full sized coveralls, worn by sensored manikins, were exposed to fuel fires to gain knowledge of what happens to the suits in realistic fuel fires.

MATERIAL

THE FUEL FIRE TEST FACILITY (FIRE PIT)

The assemblies were tested at the NAVAIRDEVCEN FUEL FIRE TEST FACILITY, illustrated in Figure 1. It consists of a pool of water 25 feet x 20 feet and about 8 inches deep contained in a concrete base 18 inches high. The surface of the water is divided into 20 cells by an angle aluminum grid, each cell being provided with a fuel nozzle. Just before each test, fuel is pumped into



NAVAIRDEVCEN FUEL FIRE TEST FACILITY

FIGURE 1. DIAGRAM OF THE FUEL FIRE TEST FACILITY, REDUCED FROM A SCALED DRAWING. THE FUEL IS IGNITED BY FOUR AIR PROPANE IGNITERS AT LOCATIONS X. THE COMPOUND IS ENCLOSED BY A CORRUGATED STEEL FENCE AND THE FIRE PIT IS LOCATED ABOUT 20' INSIDE THE FENCE ON THREE SIDES. THE 8' CONCRETE BLOCK WALL IS SHOWN ON THE FOURTH SIDE. (SEE TEXT)

the pool through the nozzles and allowed to rise to the top of the water spreading on the surface to give an even distribution. Four air propane igniters are arranged around the edge of the pool for ignition. The fuel in these tests was JP-4.

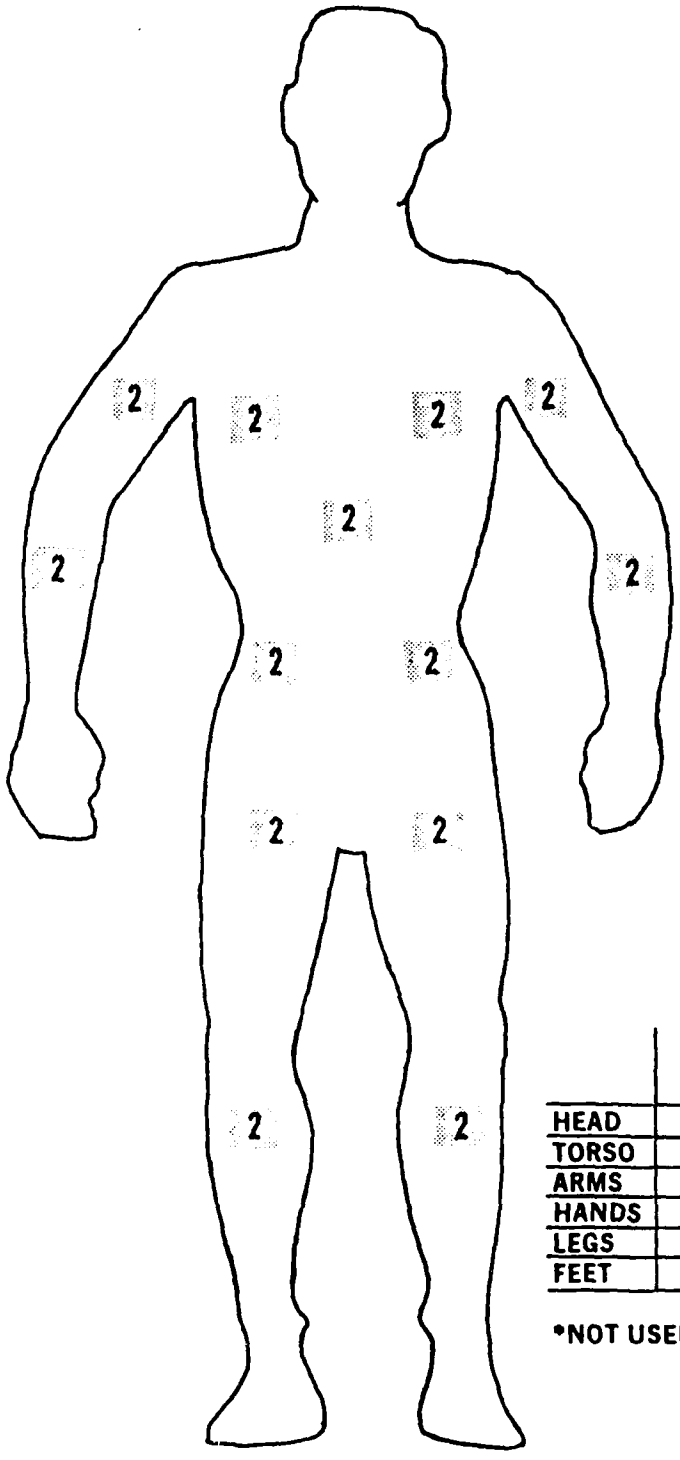
The fire pit (pool) is surrounded on three sides by a 12-foot fence which is located about 20 feet from the pit. On the fourth side is a concrete block wall 10 feet high behind which operations are carried out. Also located on the operations side of the wall is the base of a rotating jib crane which carries a manikin dressed in the test garment through the flames.

THE TEST MANIKINS

Fiberglass manikins coated with fire resistant paint were employed in these tests. The surface of the manikin was covered by 26 sensor patches placed at predetermined locations on the body, illustrated in Figure 2. These locations are identified on Table I where the abbreviations in the left column are useful for locating the sensors as they appear in the Accumulated Data of Appendix A. The torso contained 10 sensor patches, the arms 8, and the legs 8. Leather patches containing six adhesive-backed paper sensors were designated for 250° F through 300° F in 10° F increments. The sensors changed color permanently (the color change is from silvery-white to black) when the designated temperature was reached.

Table I. Location of Sensors on the Manikin Surface: Sensor Sites

1.	UT2F	Upper Torso 2 Front
2.	UT2B	Upper Torso 2 Back
3.	UT3F	Upper Torso 3 Front
4.	UT3B	Upper Torso 3 Back
5.	UT6F	Upper Torso 6 Front
6.	UT6B	Upper Torso 6 Back



	% BODY SURFACE	NO. SENSORS
HEAD	7	4*
TORSO	35	10
ARMS	14	8
HANDS	5	4*
LEGS	32	8
FEET	7	2*

*NOT USED

FIGURE 2. THE FIGURE SHOWS THE LOCATION OF THE SENSOR PATCHES ON THE MANIKIN'S SURFACE. THE NUMBER 2 REPRESENTS ONE SENSOR PATCH ON THE FRONT OF THE MANIKIN AND A CORRESPONDING SENSOR PATCH ON THE BACK.

7.	LT1F	Lower Torso 1 Front
8.	LT1B	Lower Torso 1 Back
9.	LT2F	Lower Torso 2 Front
10.	LT2B	Lower Torso 2 Back
11.	RA1F	Right Upper Arm 1 Front
12.	RA1B	Right Upper Arm 1 Back
13.	RA2F	Right Lower Arm 2 Front
14.	RA2B	Right Lower Arm 2 Back
15.	LA1F	Left Upper Arm 1 Front
16.	LA1B	Left Upper Arm 1 Back
17.	LA2F	Left Lower Arm 2 Front
18.	LA2B	Left Lower Arm 2 Back
19.	RL1F	Right Leg 1 Front
20.	RL1B	Right Leg 1 Back
21.	RL3F	Right Leg 3 Front
22.	RL3B	Right Leg 3 Back
23.	LL1F	Left Leg 1 Front
24.	LL1B	Left Leg 1 Back
25.	LL3F	Left Leg 3 Front
26.	LL3B	Left Leg 3 Back

PROCEDURE

TEST ENSEMBLES

Table II lists the types of materials, the test code given to each material, the numbers tested of each, the weight of the material and the color.

Table II. Characteristics of the Assemblies

Material	Code	No. Tested	Weight(oz/yd^2)	Color
40/60 PBI/Kevlar	PBIY	5	4.5 oz.	gold
20/80 PBI/Nomex	PBIB	5	4.7 oz.	blue
100% Nomex	STDG	6	4.5 oz.	green

DRESSING THE MANIKINS

The sensored manikins were dressed in summer underwear and black wool socks that came up to the manikins' knees, and the test uniform. The socks

afforded protection from the heat to the lower legs. Standard leather ankle high boots were put on the manikins' feet. Care was also taken to tighten the velcro around the wrists and ankles to prevent heat from traveling up a loose sleeve or coverall leg. The dressed manikin was then mounted to the manikin frame of the crane behind the concrete block wall.

OPERATION OF THE FACILITY

In operation, the pit is fueled, ignited, and the fire allowed to develop for about 15-20 seconds. Then the crane carrying the manikin is started from a point behind the wall. The crane controller is set so that the dressed manikin is in the flames for the required number of seconds. The manikin travels back behind the wall after it goes through the flames and is photographed by two movie cameras as it comes out of the flames. Information on the placement of cameras is discussed below. As the manikin rounds the wall and approached its starting position it is viewed by a hand held video camera. Additional general information on the Fire Pit Facility and the Procedure has been reported elsewhere (1).

During the period of exposure, the heat flux is measured by a HY CAL[1] transducer which is located near the manikin's waist. The signal from the transducer is printed on a strip chart recorder for each test. Heat flux is later obtained by integrating the trace with a planimeter. Listed below is the schedule of tests according to the duration of the exposure.

[1] HY-CAL ENGINEERING SANTA FE SPRINGS, CA.

Test Exposures by Serial Number

	3 second	4 second
PBI/Kevlar	372	366
	375	368
	377	
PBI/Nomex	373	365
	376	369
	378	
Nomex III	371	364
	374	367
	379	
	380	

After the completion of each test the manikin, still dressed in the flight suit, is photographed front, side and back. The same three views are recorded on video tape. The flight suit is visually inspected for shrinkage mainly around the arms and legs. At a later time the photographs showing the lengths of the trousers and sleeves before the exposure can be compared to those after the test. No numerical values are recorded for these observations.

The manikin was undressed and the temperatures of the activated tapes were recorded for later determination of the total heat exposure. The activation temperatures of the tapes were computed to percent burn injury by body region for each test by a FORTRAN program that produced the raw data tables of Appendix A and Table III. The percent body burned obtained is related to the total heat of exposure, consisting of the heat flux (cal/cm^2) and the duration (seconds).

PHOTOGRAPHIC AND TV COVERAGE

Two video cameras view the fire pit area from outside the fence. The cameras are placed at locations labeled CAMERA 1 and CAMERA 2 in Figure 1.

Both cameras operate into a single split screen monitor so that both views can be seen simultaneously. They can also be played back immediately after the test. A hand held TV camera, CAMERA 3, with a zoom lens, its own video-cassette recorder (VCR) and monitor is also used. It records the frontal aspect of the test assembly as it appears from behind the wall and afterward when the exposure is completed. As seen in Figure 1, the CAMERA 3 operator stands in the doorway, directly facing the operations side of the wall. This view is particularly good for observing any possible after flaming of the test assembly.

RESULTS

The results of these tests are given in: Appendix A and Table III. Appendix A contains the raw test data for each assembly, at the top of each small table is the Heat Flux, the Time of Exposure in seconds and the Identification Number. The manikin body site is abbreviated in the first column of each listing (refer to Table I). If a paper sensor turned black during the test its value is written out, if not, a zero is entered. These values are summarized according to the scheme referred to previously (2) and shown in Figure 2. In these tests only the torso, arms and legs were evaluated as there were no hoods, gloves or foot wear being tested. Percentage body burned was evaluated at a paper sensor temperature of 250^{o} F that would cause a blister on the skin of a human.

These raw test results are summarized in Table III. This Table identifies each test with its heat flux, the duration of the exposure, an analysis of the percent burned by region of the body, the total of these regions and a description of the material. It should be noted that in two of the tests (373

TABLE III. PERCENT BODY BURNED AT 250 F FOR THE CELANESE TESTS

IDENTIFICATION	FLUX (CAL/CM2)	DURATION SEC	PERCENT BODY BURNED TORSO	ARMS	LEGS	TOTAL B.B.	DESCRIPTION
PBIY 6190 366	5.[illegible]	4	24.50	14.00	20.00	58.50	CELANESE 40% PBI/60% KEVLAR FLIGHT SUIT
PBIY 6190 368	7.59	4	14.00	12.25	12.00	38.25	
PBIY 6210 372	10.09	3	0.00	10.50	16.00	26.50	
PBIY 6210 375	10.81	3	0.00	10.50	12.00	22.50	
PBIY 6210 377	7.66	3	3.50	8.75	8.00	20.25	
PBIB 6190 365	7.43	4	14.00	14.00	16.00	44.00	CELANESE 20% PBI/80% NOMEX BLUE FLT SUIT
PBIB 6190 369	5.03	4	10.50	12.25	12.00	34.75	
PBIB 6210 373	0.00	3	7.00	7.00	12.00	26.00	
PBIB 6210 376	8.86	3	0.00	5.25	12.00	17.25	
PBIB 6210 378	8.80	3	0.00	5.25	4.00	9.25	
STDG 6190 364	0.00	4	10.50	14.00	12.00	36.50	27/P SAGE GREEN NOMEX FLIGHT SUIT
STDG 6190 367	4.55	4	17.50	12.25	16.00	45.75	
STDG 6210 371	5.85	3	0.00	1.75	0.00	1.75	
STDG 6210 374	10.12	3	14.00	12.25	12.00	38.25	
STDG 6210 379	7.80	3	7.00	7.00	16.00	30.00	
STDG 6210 380	15.38	3	21.00	14.00	16.00	51.00	

and 364) no heat flux reading was obtained due to technical difficulties.

In Figure 3, the heat flux is plotted against the percentage body burned for all sixteen tests. This shows the wide variation in heat flux among the tests, also the heat flux for the 4-second tests in most cases is less than the heat flux for the 3-second tests. This apparent discrepancy may be due to different wind conditions on the days of the tests, and only one calorimeter may give inaccurate results considering the randomness with which the fire burns. Modifications are being made so that in the future at least four points will be instrumented with calorimeters.

Figure 4 was plotted from the 3 second exposures that had flux readings of 9 $cal/cm^2 \pm 2$ cal/cm^2 in order to make some comparisons between the two PBI blends and Nomex III. These points are also shown circled on the Figure 3 graph to illustrate where they fit in the overall test results. The average percent body burned for each group of materials (Figure 4 test points) is listed in Table IV:

Table IV. Average Percent Body Burned
for the tests plotted in Figure 4

Material	% Body Burned
20/80 PBI/Nomex I	13.25%
40/60 PBI/Kevlar	23.08%
Nomex III	34.13%

40/60 PBI/KEVLAR

Total heat exposure from these tests ranged from 5.33 cal/cm^2 to 10.81 cal/cm^2 and the burn injury estimates ranged from 20.25 to 58.50 percent. The average total heat exposure was 8.30 cal/cm^2 and the average estimated burn injury was 33.20 percent for the five tests. Overall the PBI/Kevlar uniforms had higher percent body burned than the PBI/Nomex I coveralls.

Figure 5 shows the front view of the coverall on the manikin before the

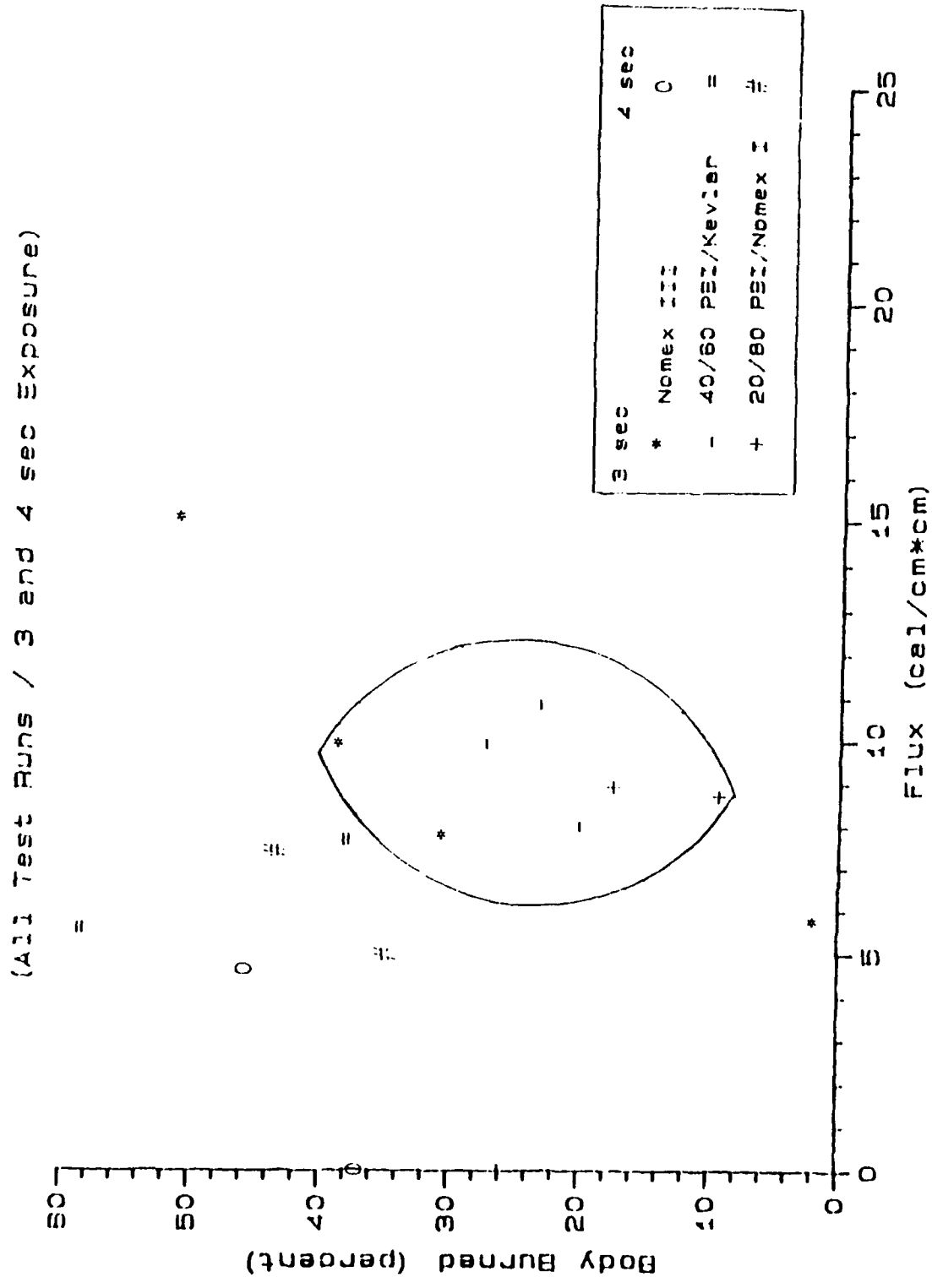


FIGURE 5. PERCENT BODY BURNED VS. HEAT FLUX FOR ALL TESTS IN THE CELANESE SERIES. (THE CIRCLED 3 SECOND POINTS WITH SIMILAR FLUX SHOW WHERE THE FIGURE 4 GRAPH FITS WITHIN THE OVERALL TEST PATTERN.)

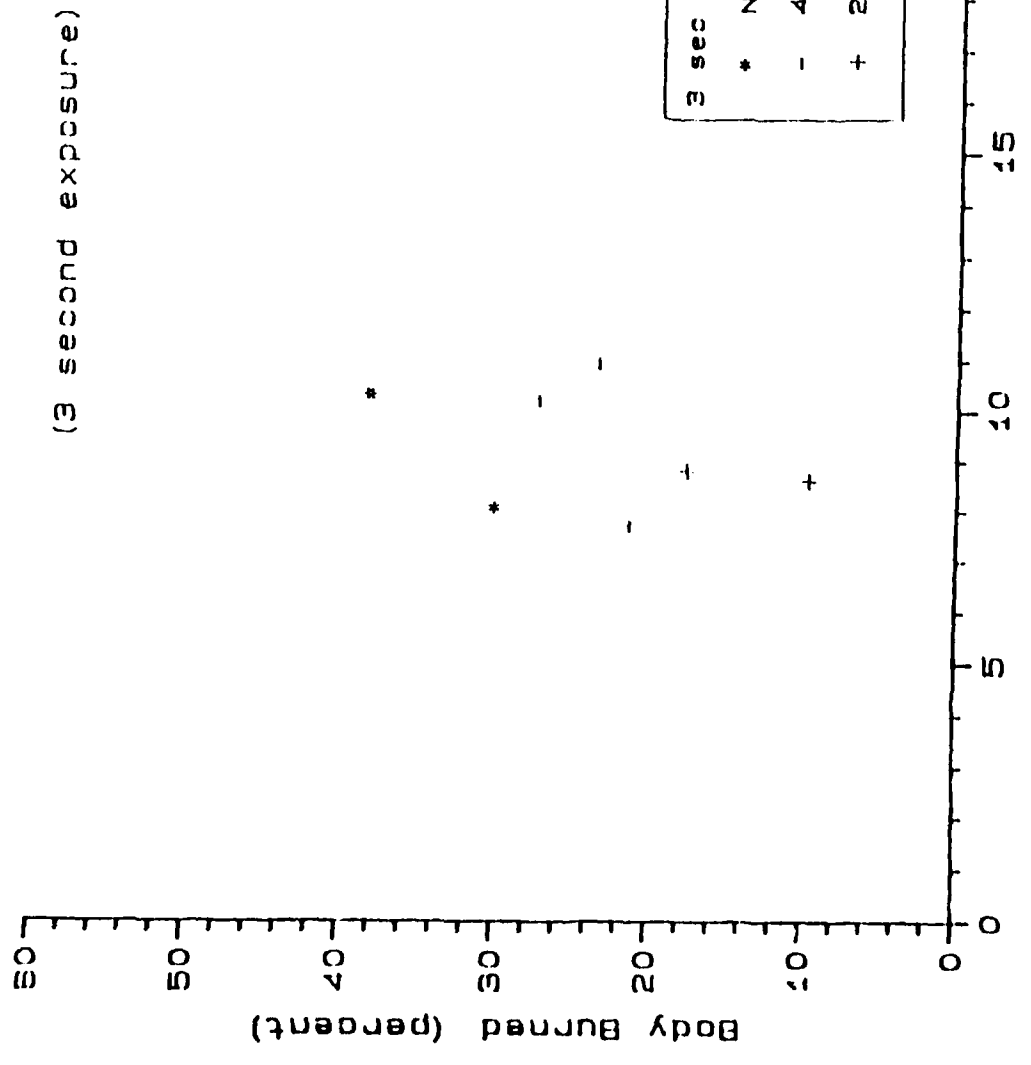


FIGURE 4. PERCENT BODY BURNED VS. HEAT FLUX FOR THE 3 SECOND TESTS WITH SIMILAR FLUX. (BECAUSE OF THE WIDELY VARYING HEAT FLUX, THESE POINTS WERE CHOSEN TO BE ABLE TO MAKE COMPARISONS BETWEEN THE THREE TYPES OF SUITS TESTED.)

test and Figure 6 shows the same view after the test. Figures 7 and 8 show before and after views of the side. Figures 9 and 10 are representative views of the before and after of the back.

It can be seen from these photographs that the integrity of the uniform was maintained after exposure to the fuel fire. There is no cracking or shrinkage and the material remains supple.

20/80 PBI/NOMEX I

Again, five suits were tested, the first two were exposed to a 4 second fuel fire, while the last three tests experienced a three second fire. Total heat exposure from these five tests ranged from 5.03 cal/cm^2 to 8.86 cal/cm^2. Burn injury estimates ranged from 9.25 to 44.00 percent. The average total heat was 7.53 cal/cm^2 and the average estimated burn injury was 26.25 percent. Overall the PBI/Nomex I coveralls had the lowest percent body burned out of the three groups of coveralls tested.

Figures 11 and 12 show the front of the coverall before and after the test, respectively; Figures 13 and 14 show the side views before and after the test; and Figures 15 and 16 are the back views of the coverall before and after the test, respectively.

Although the suits still had some shrinkage the affected areas were not as brittle as seen in the Nomex III suits. There was discoloration which appeared to be caused by direct contact with the flames, so that the regular dark blue color turned beige in the affected areas. However the discolored areas did not crumble away when handled.

NOMEX III

Six suits were tested in this group: the first two suits were run at four seconds and the remaining four were run at three seconds. The total heat

exposures ranged from 4.55 cal/cm^2 to 15.38 cal/cm^2. Burn injury estimates ranged from 1.75 to 51.00 percent. The average total heat exposure was 8.74 cal/cm^2 sec and the average estimated burn injury was 33.88 percent. Overall the Nomex III coverall had the highest percent body burned.

Figure 17 shows the front of the coverall before fire testing. Figure 18 shows the corresponding view after testing. Likewise Figures 19 and 20 show the before and after views of the side of the coverall and Figures 21 and 22 show the back views before and after the tests.

As seen in the photographs, especially the arms and legs of the Nomex III coverall showed extensive shrinking. The material, in places, became very brittle and would crumble upon handling.

Figure 23 shows three manikins wearing the three different types of coveralls after being through a full scale fire test. From left to right is Nomex III, 40/60 PBI/Kevlar and the 20/80 PBI/Nomex I flight suits.

DISCUSSION

We compared the characteristics of the materials with regard to potential protection offered to the wearer. This comparison is shown in Figure 4 where percent body burned is plotted as a function of the heat flux measured by the calorimeter. Three second tests that had heat flux within the same range, 9 cal/cm^2 $\pm$ 2 cal/cm^2, were evaluated in this comparison. Two tests of the Nomex III coveralls, three tests of the PBI/Kevlar and two tests of the PBI/Nomex I tests were used in Figure 4.

The PBI/Nomex blend has the least percent body burned at 13.25%, while the PBI/Kevlar comes in second at 23.08%. The Nomex III had the highest percent body burned at 34.13%.

Although the PBI/Kevlar was second in percent body burned, the fabric itself withstood the fuel fire very well as was seen in the photographs (Figures 5 to 10) and in the video tapes. It showed only slight visible effects from the fire and it was as soft and flexible as before testing.

In addition, the 20/80 PBI/Nomex I coveralls exhibited other favorable characteristics when compared to Nomex III. These characteristics were: a reduction in the percent body burned, a reduction in the amount of shrinkage and the absence of brittleness. Therefore, the PBI/Nomex I blend would be expected to provide the best protection to the wearer in a fire as indicated in these tests.

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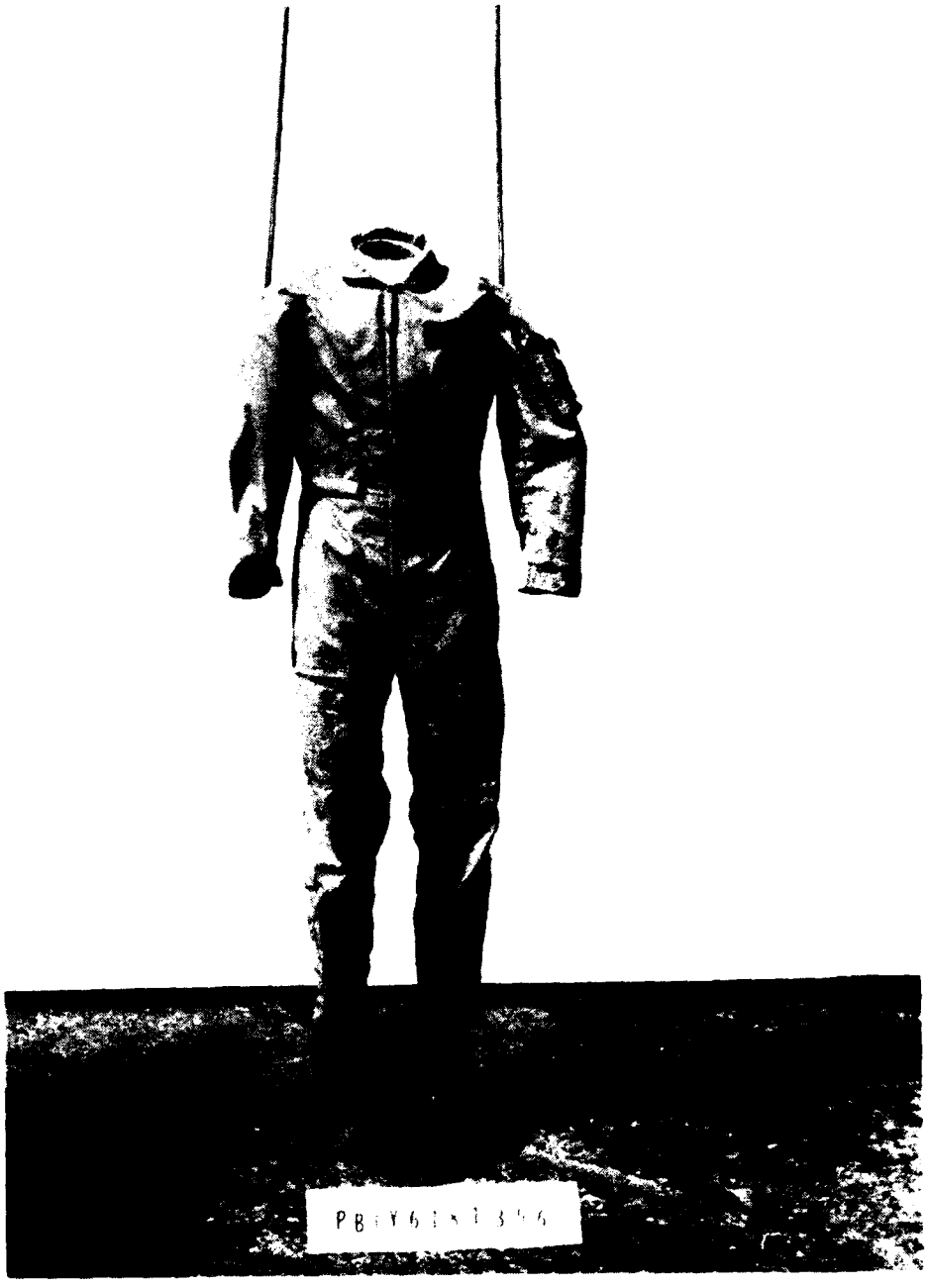

Figure 5. **40/60 PBI/Kevlar (Front, Before)**

Figure 6. **40/60 PBI/Kevlar (Front, After)**

Figure 7. **40/60 PBI/Kevlar (Side, Before)**

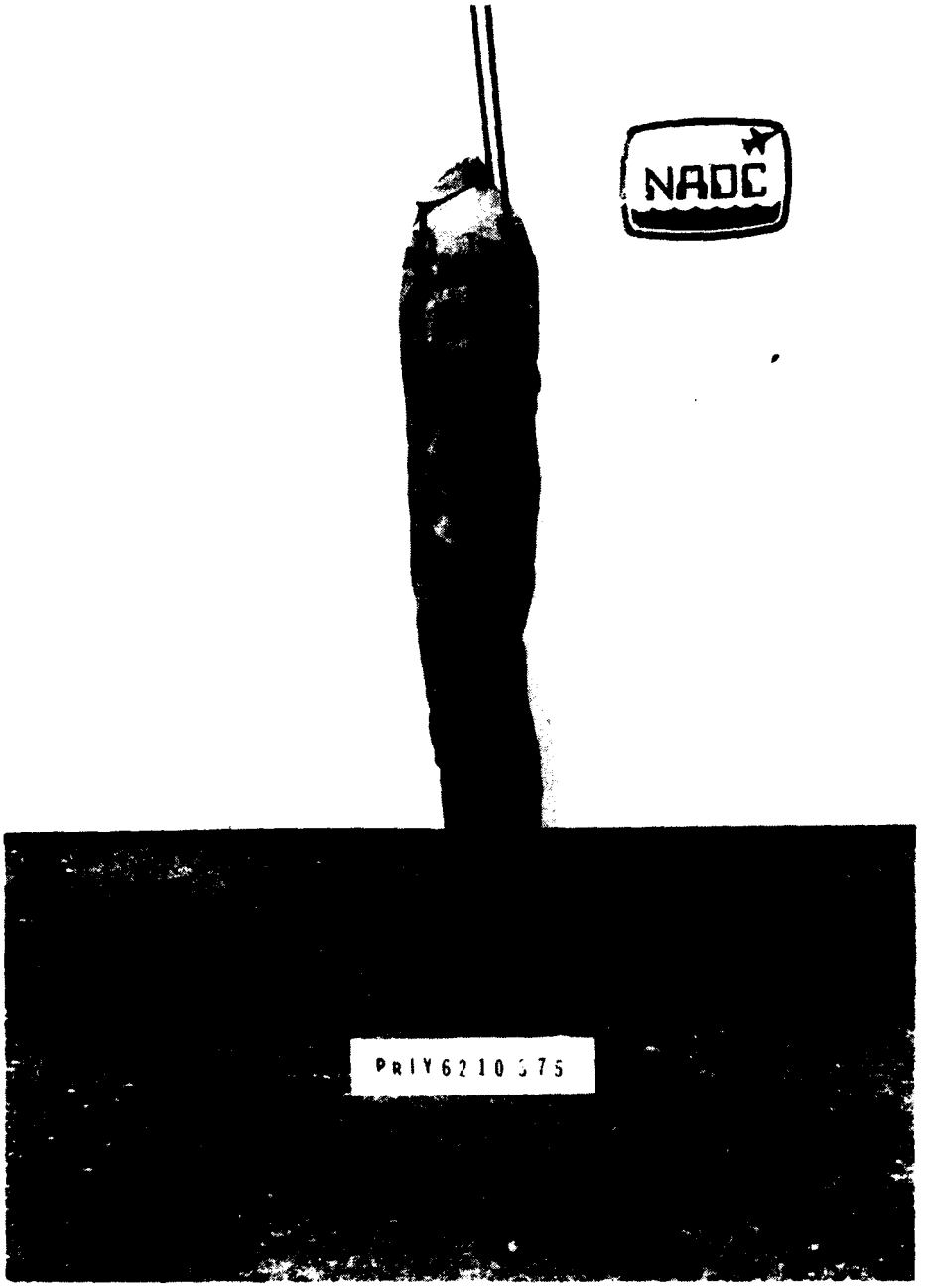

Figure 8. **40/60 PBI/Kevlar (Side, After)**

Figure 9. **40/60 PBI/Kevlar (Back, Before)**

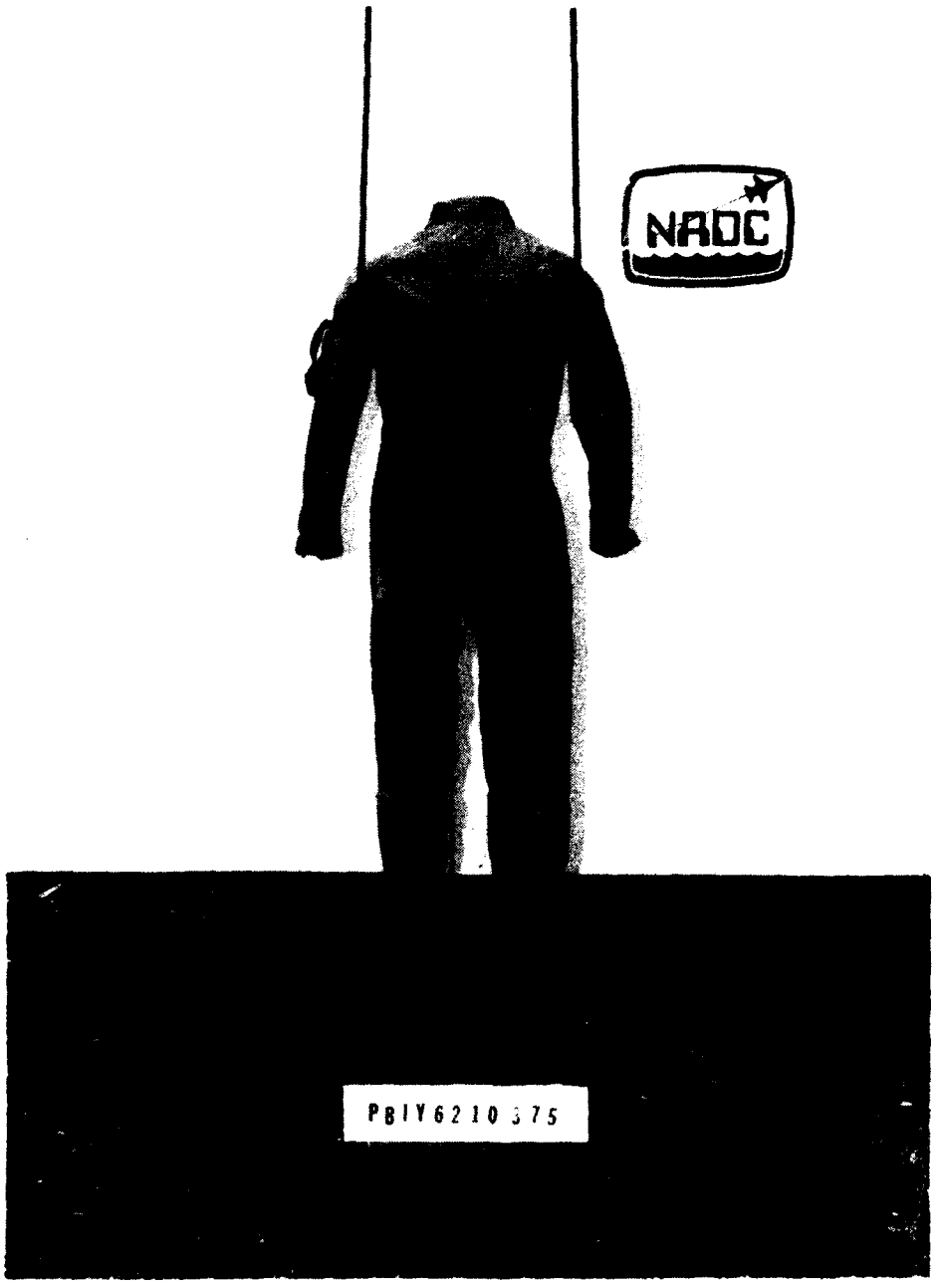

Figure 10. **40/60 PBI/Kevlar (Back, After)**

Figure 11. **20/80 PBI/Nomex I (Front, Before)**

Figure 12. **20/80 PBI/Nomex I (Front, After)**

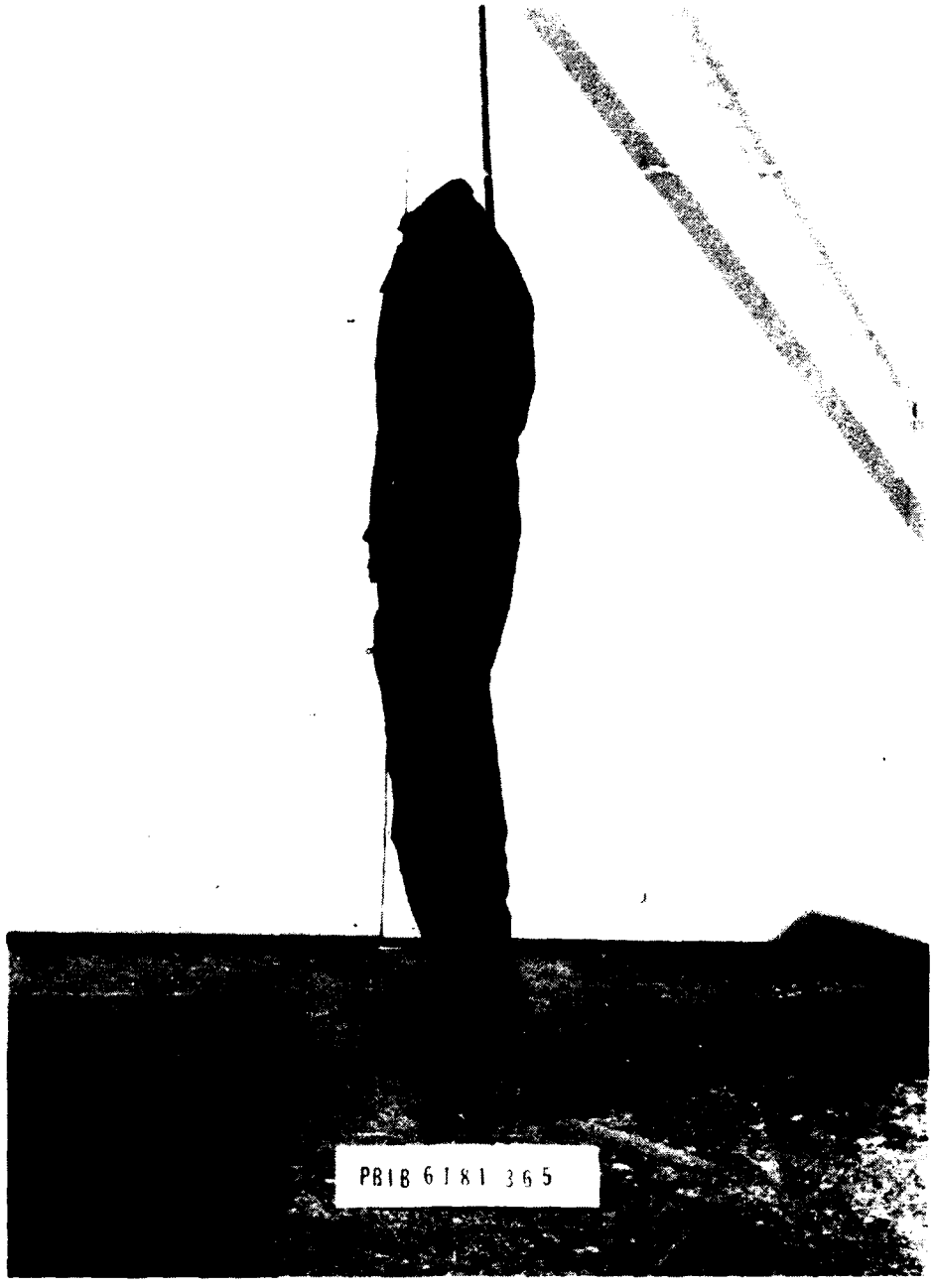

Figure 13. **20/80 PBI/Nomex I (Side, Before)**

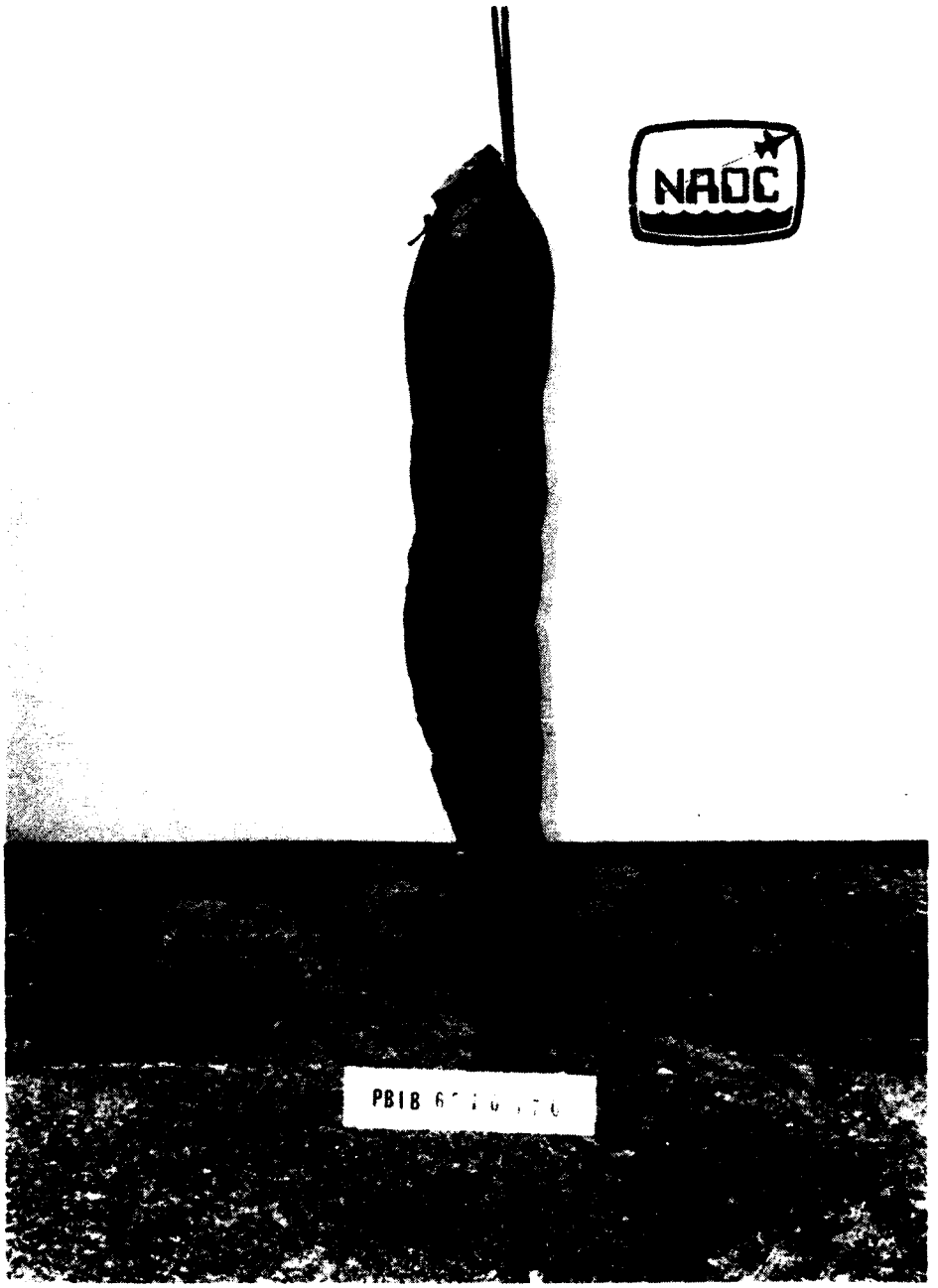

Figure 14. **20/80 PBI/Nomex I (Side, After)**

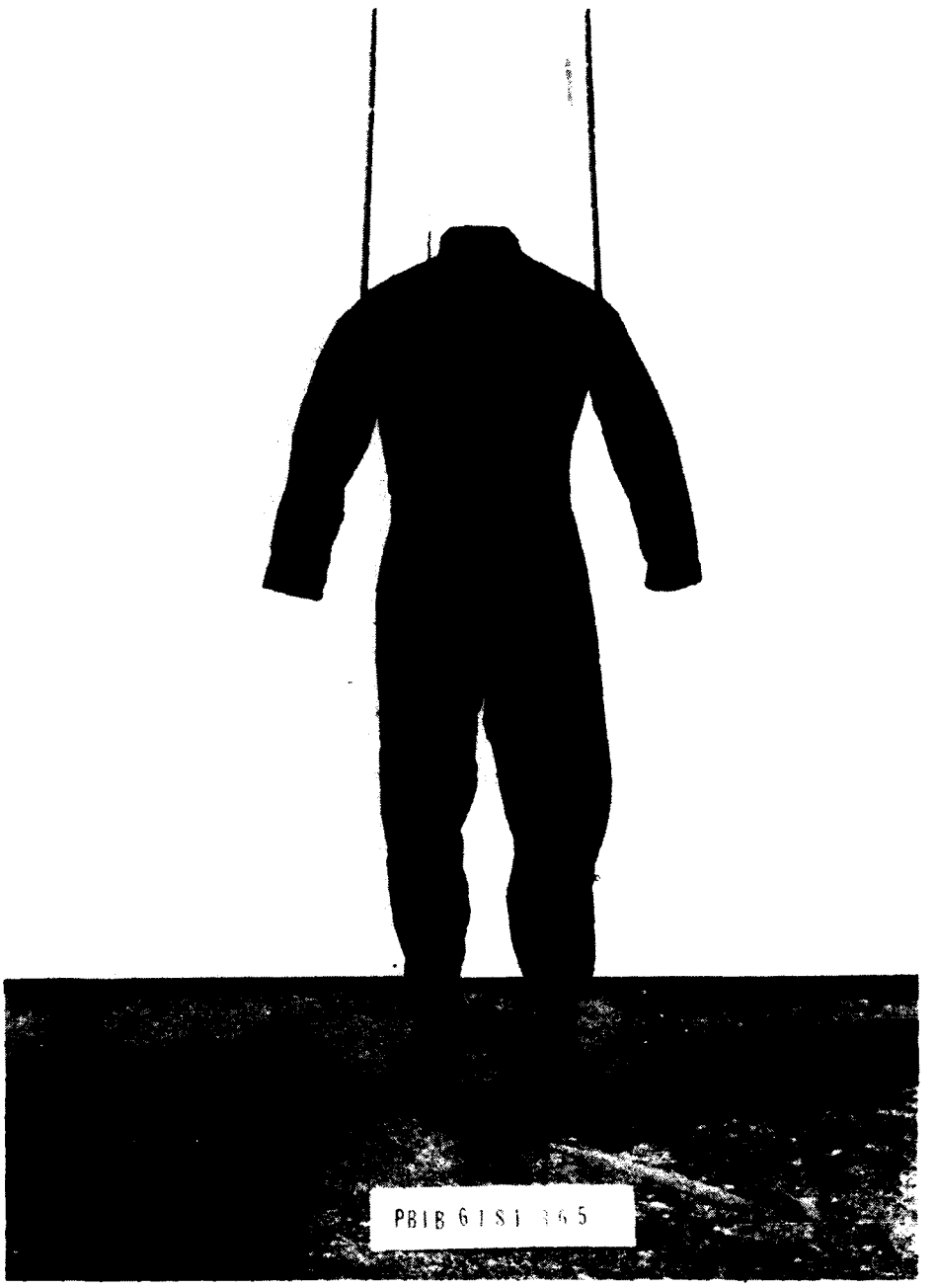

Figure 15. **20/80 PBI/Nomex I (Back, Before)**

Figure 16. **20/80 PBI/Nomex I (Back, After)**

Figure 17. **Standard Nomex III (Front, Before)**

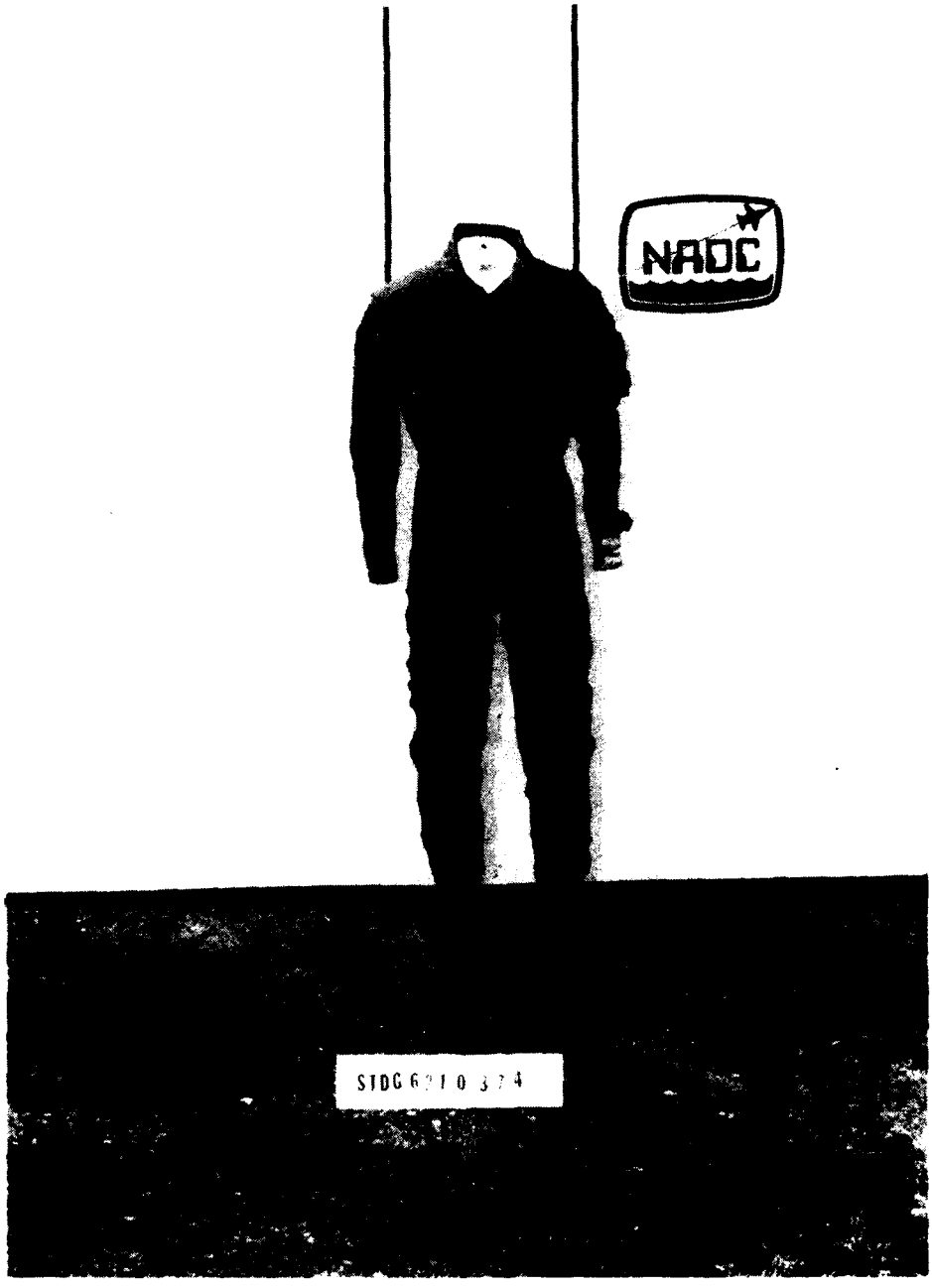

Figure 18. **Standard Nomex III (Front, After)**

Figure 19. **Standard Nomex III (Side, Before)**

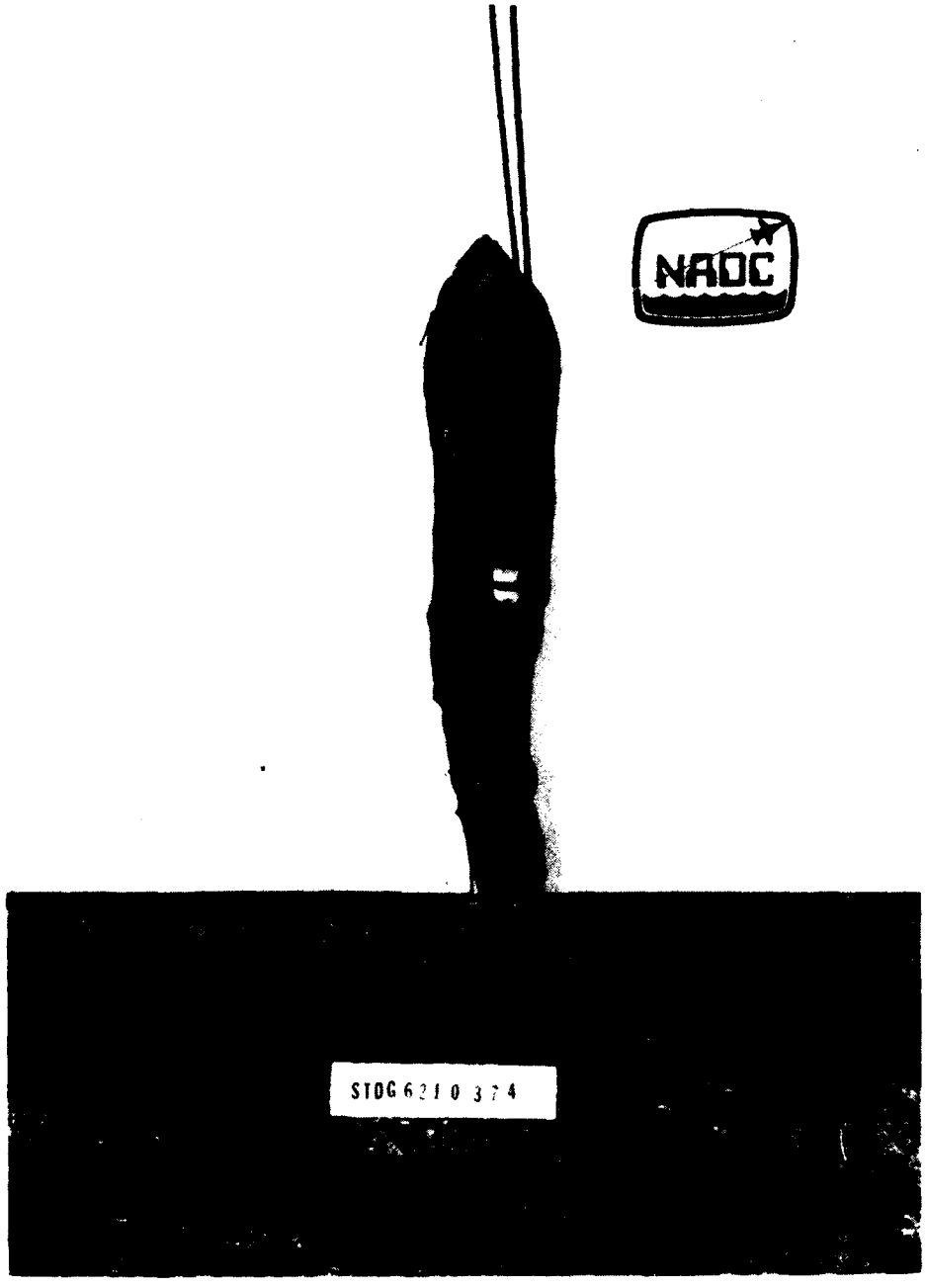

Figure 20. **Standard Nomex III (Side, After)**

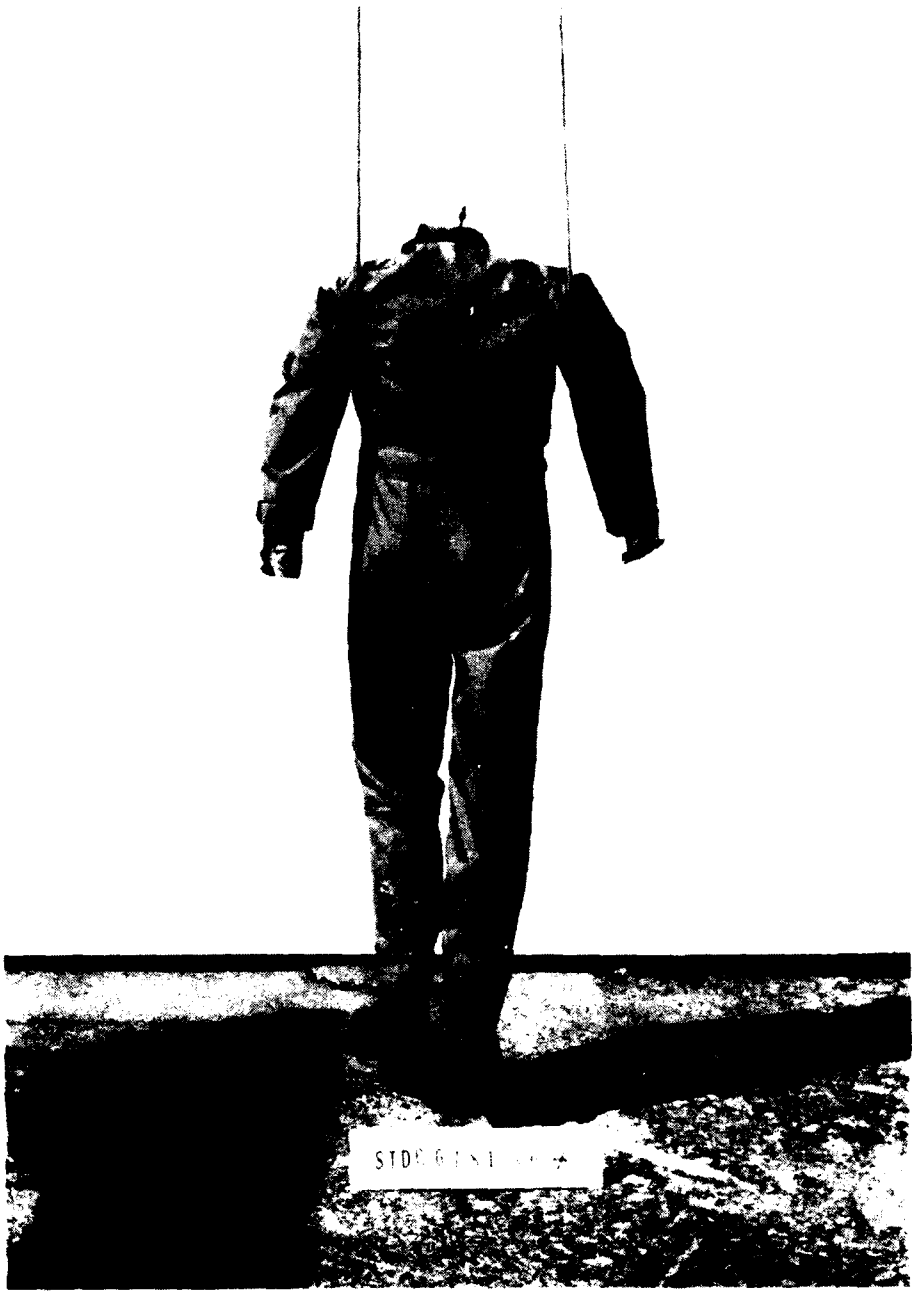

Figure 21. **Standard Nomex III (Back, Before)**

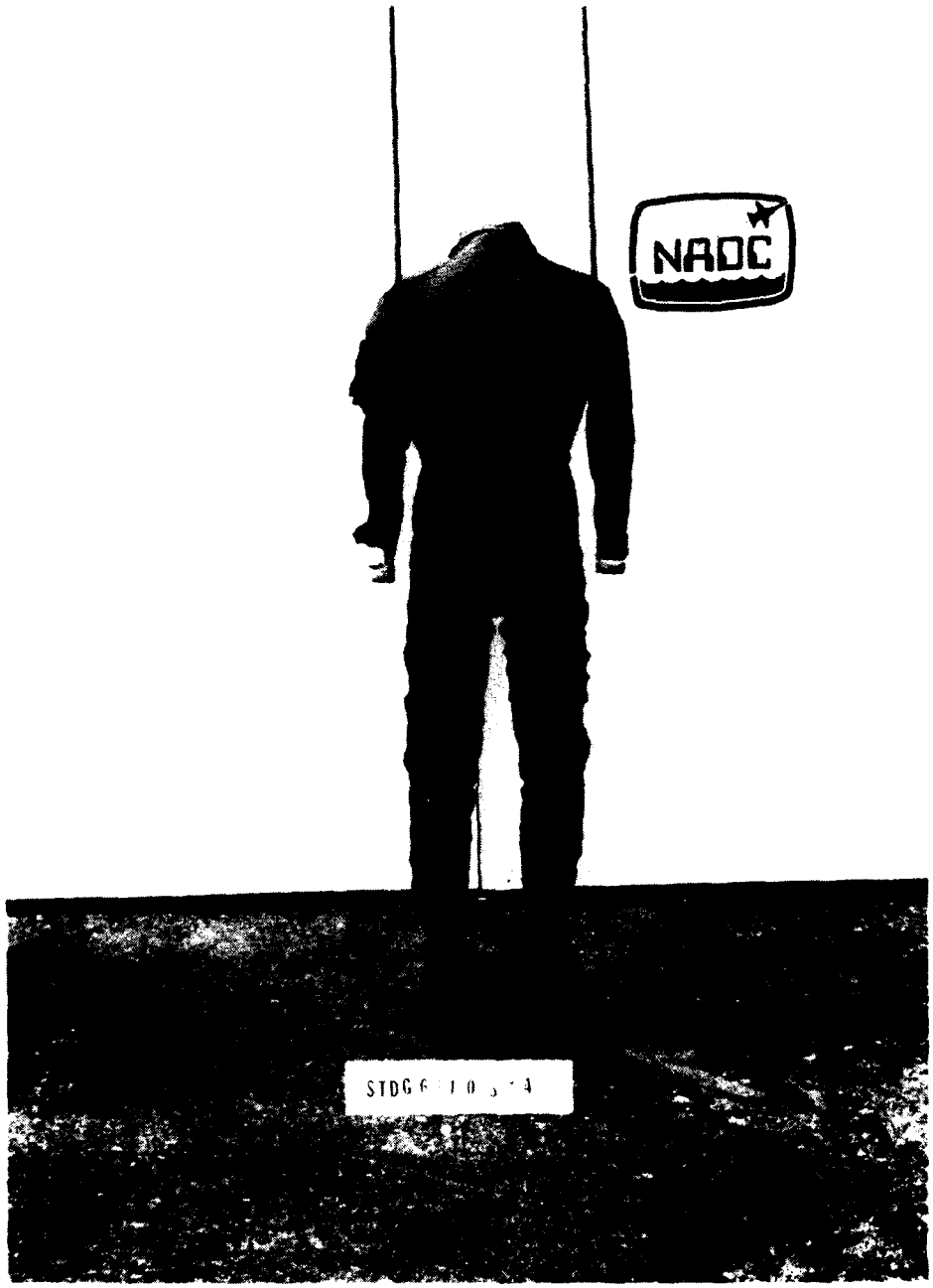

Figure 22 Standard Nomex III (Back, After)

Figure 23. **A comparison of the three different types of suits tested from left to right: Standard 100% Nomex III, 40/60 PBI/Kevlar, and 20/80 PBI/Nomex I.**

APPENDIX A

Accumulated Run Data

STDG6190364 4 SEC 0.00 CAL/CM2

UT2F	240	250	0	0	0	0
UT2B	240	250	260	270	280	290
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	0	0
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	280	290
LA1B	240	250	260	270	280	0
LA2F	240	250	260	270	280	0
LA2B	240	250	260	270	280	290
RL1F	0	0	0	0	0	0
RL1B	240	250	260	270	280	290
RL3F	240	250	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	0	0	0	0	0	0
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

PBIB6190365 4 SEC 7.43 CAL/CM2

UT2F	240	250	260	0	0	0
UT2B	240	250	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	240	250	260	270	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	0	0	0	0
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	280	290
LA1B	240	250	260	270	280	0
LA2F	240	250	260	270	280	290
LA2B	240	250	260	270	280	290
RL1F	240	250	260	270	280	0
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	0	0	0	0
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

PBIY6190366 4 SEC 5.33 CAL/CM2

UT2F	240	250	260	270	280	0
UT2B	240	250	260	270	280	290
UT3F	240	250	260	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	240	250	260	270	280	290
LT1F	0	0	0	0	0	0
LT1B	240	250	260	270	280	290
LT2F	0	0	0	0	0	0
LT2B	240	250	260	270	280	290
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	280	290
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	0	0
LA1B	240	250	260	270	280	290
LA2F	240	250	260	270	280	290
LA2B	240	250	260	270	280	290
RL1F	240	250	260	270	280	290
RL1B	240	250	260	270	280	290
RL3F	240	0	0	0	0	0
RL3B	240	250	260	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	240	0	0	0	0	0

STDG6190367 4 SEC 4.55 CAL/CM2

UT2F	0	0	0	0	0	0
UT2B	240	250	260	270	280	290
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	240	250	260	270	280	290
LT1B	240	250	260	270	0	0
LT2F	0	0	0	0	0	0
LT2B	240	250	260	270	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	280	0
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	280	290
LA1B	0	0	0	0	0	0
LA2F	240	250	260	270	280	0
LA2B	240	250	260	270	280	290
RL1F	0	0	0	0	0	0
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	0	0
LL1B	240	250	260	270	280	290
LL3F	240	250	260	0	0	0
LL3B	0	0	0	0	0	0

PBIY6190368 4 SEC 7.59 CAL/CM2

UT2F	240	250	0	0	0	0
UT2B	240	250	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	240	250	260	270	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	280	290
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	280	290
LA1B	240	250	260	270	280	0
LA2F	0	0	0	0	0	0
LA2B	240	250	260	270	280	290
RL1F	240	250	260	270	280	290
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	240	0	0	0	0	0
LL1F	0	0	0	0	0	0
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	240	0	0	0	0	0

PBIB6190369 4 SEC 5.03 CAL/CM2

UT2F	0	0	0	0	0	0
UT2B	240	250	260	270	280	290
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	240	250	260	270	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	280	290
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	280	290
LA1B	240	250	260	270	280	290
LA2F	0	0	0	0	0	0
LA2B	240	250	260	270	280	290
RL1F	0	0	0	0	0	0
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	0
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

Accumulated Run Data (Continued)

STDG6210371	3 SEC			5.85	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	0	0	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	0	0	0	0	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	0	0	0	0	0	0
RA1B	0	0	0	0	0	0
RA2F	0	0	0	0	0	0
RA2B	0	0	0	0	0	0
LA1F	0	0	0	0	0	0
LA1B	0	0	0	0	0	0
LA2F	240	250	260	270	0	0
LA2B	0	0	0	0	0	0
RL1F	0	0	0	0	0	0
RL1B	0	0	0	0	0	0
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	0	0	0	0	0	0
LL1B	0	0	0	0	0	0
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

PBIY6210372	3 SEC			10.09	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	0	0	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	0	0	0	0	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	0	0
RA2F	0	0	0	0	0	0
RA2B	240	250	260	270	280	290
LA1F	240	250	0	0	0	0
LA1B	0	0	0	0	0	0
LA2F	240	250	260	270	280	290
LA2B	240	250	260	270	0	0
RL1F	240	250	260	0	0	0
RL1B	240	250	260	0	0	0
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

PBIB6210373	3 SEC			0.00	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	240	250	260	270	280	290
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	0	0	0	0	0
RA1B	240	250	260	270	280	290
RA2F	240	0	0	0	0	0
RA2B	240	250	260	270	0	0
LA1F	240	250	260	270	280	290
LA1B	0	0	0	0	0	0
LA2F	240	250	260	0	0	0
LA2B	0	0	0	0	0	0
RL1F	0	0	0	0	0	0
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

STDG6210374	3 SEC			10.12	CAL/CM2	
UT2F	240	250	260	270	0	0
UT2B	240	250	260	270	280	290
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	240	250	260	270	280	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	240	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	0	0	0	0	0	0
RA2F	240	250	260	270	280	0
RA2B	240	250	260	270	0	0
LA1F	240	250	260	270	280	290
LA1B	240	250	260	270	280	290
LA2F	240	250	260	0	0	0
LA2B	240	250	260	270	280	290
RL1F	0	0	0	0	0	0
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

PBIY6210375	3 SEC			10.81	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	0	0	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	240	0	0	0	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	0	0	0	0	0	0
RA1B	240	250	260	270	280	290
RA2F	240	250	260	270	0	0
RA2B	240	250	260	270	280	290
LA1F	0	0	0	0	0	0
LA1B	240	250	260	270	0	0
LA2F	240	250	260	0	0	0
LA2B	240	250	260	270	280	290
RL1F	0	0	0	0	0	0
RL1B	0	0	0	0	0	0
RL3F	240	0	0	0	0	0
RL3B	240	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	0	0	0	0	0
LL3F	240	250	260	270	280	290
LL3B	240	250	0	0	0	0

PBIB6210376	3 SEC			9.86	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	0	0	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	0	0	0	0	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	0	0	0	0	0	0
RA2F	0	0	0	0	0	0
RA2B	240	250	260	270	280	290
LA1F	0	0	0	0	0	0
LA1B	0	0	0	0	0	0
LA2F	0	0	0	0	0	0
LA2B	240	250	260	270	280	290
RL1F	240	250	260	270	280	290
RL1B	240	250	260	270	280	0
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	0
LL1B	0	0	0	0	0	0
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

Accumulated Run Data (Continued)

PB1Y6210377	3 SEC			7.66	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	0	0	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	0	0	0	0	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	240	250	260	270	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	0
RA1B	0	0	0	0	0	0
RA2F	240	0	0	0	0	0
RA2B	240	250	0	0	0	0
LA1F	240	250	0	0	0	0
LA1B	240	250	260	270	0	0
LA2F	240	250	260	270	280	290
LA2B	0	0	0	0	0	0
RL1F	0	0	0	0	0	0
RL1B	240	250	260	270	0	0
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	0	0
LL1B	240	0	0	0	0	0
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

PB1B6210378	3 SEC			8.80	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	0	0	0	0	0	0
UT3F	0	0	0	0	0	0
UT3B	0	0	0	0	0	0
UT6F	0	0	0	0	0	0
UT6B	0	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	0	0	0	0	0	0
RA1B	0	0	0	0	0	0
RA2F	0	0	0	0	0	0
RA2B	240	250	260	0	0	0
LA1F	240	0	0	0	0	0
LA1B	0	0	0	0	0	0
LA2F	240	250	260	270	280	290
LA2B	240	250	260	270	280	0
RL1F	0	0	0	0	0	0
RL1B	0	0	0	0	0	0
RL3F	0	0	0	0	0	0
RL3B	240	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	0	0	0	0	0	0
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

STDG6210379	3 SEC			7.80	CAL/CM2	
UT2F	0	0	0	0	0	0
UT2B	240	250	260	0	0	0
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	0	0	0	0	0	0
UT6B	240	0	0	0	0	0
LT1F	0	0	0	0	0	0
LT1B	0	0	0	0	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	0	0	0	0	0	0
RA2F	0	0	0	0	0	0
RA2B	0	0	0	0	0	0
LA1F	0	0	0	0	0	0
LA1B	240	250	0	0	0	0
LA2F	240	250	260	270	280	290
LA2B	240	250	260	270	0	0
RL1F	240	250	260	270	0	0
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

STDG6210380	3 SEC			15.38	CAL/CM2	
UT2F	240	250	260	270	0	0
UT2B	240	250	260	270	280	290
UT3F	0	0	0	0	0	0
UT3B	240	250	260	270	280	290
UT6F	240	250	260	270	0	0
UT6B	240	250	260	270	280	290
LT1F	0	0	0	0	0	0
LT1B	240	250	260	270	0	0
LT2F	0	0	0	0	0	0
LT2B	0	0	0	0	0	0
RA1F	240	250	260	270	280	290
RA1B	240	250	260	270	280	290
RA2F	240	250	260	270	280	290
RA2B	240	250	260	270	280	290
LA1F	240	250	260	270	280	290
LA1B	240	250	260	270	280	290
LA2F	240	250	260	270	280	290
LA2B	240	250	260	270	280	290
RL1F	240	250	260	270	280	290
RL1B	240	250	260	270	280	290
RL3F	0	0	0	0	0	0
RL3B	0	0	0	0	0	0
LL1F	240	250	260	270	280	290
LL1B	240	250	260	270	280	290
LL3F	0	0	0	0	0	0
LL3B	0	0	0	0	0	0

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Naval Air Station (Code 055)
Norfolk, VA 23511

Director..... 1
Defense Technical Information Center
Building 5
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United States Army
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Natick, MA 01760
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Frederick, MD 21701
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ASD/AESD
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Attn: L. Schwieterman

Hoechst Celanese Corporation.....(3 color)..... 13
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Charlotte, NC 28232

Burlington Industries, Inc..... 1
Corporate R & D Laboritories
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Greensboro, NC 27420
Attn: E. Stone

NAVAIRDEVCEN.....(1 color)..... 15
(3 for Code 8131)
(11 for Code 6023, Dr. G. Kydd)
(1 color for Code 6023, Dr. G. Kydd)